ERIC Document Resume	See Instruction Sheet	DATE OF RESUME 7/14/65	DATE RECEIVED

A. PUBLICATION DATA

1. ERIC NUMBER	2. ORIGINATOR CONTROL NO(S).	3. IDENTIFICATION NO.
ED000334	7066	N.A.

DO NOT WRITE IN SPACE BELOW

4. AUTHOR(S):
Pease, Dudley

5. TITLE OF DOCUMENT ABSTRACTED:
A Course Outline for an Introduction to Fluid Power

6. PUBLICATION TITLE:
N.A.

7. EDITOR(S):
N.A.

8. PLACE OF ORIGIN
Nat'l. Fluid Power Assoc.
ORG.
5595 N. Hollywood Ave.
STREET
Milwaukee, Wisconsin
CITY, STATE

9. PUBLISHER OR SOURCE
National Fluid Power Association

10. VOL.	11. PAGES	12. MO./YR	13. TOTAL PP.
N.A.	N.A.	59	16

TELE. EXT.
INST/LOC CODE

MICROFILM COPY AVAILABLE
YES ☒ NO ☐

COPYRIGHT GRANTED
YES ☐ NO ☒

COPYRIGHT RELEASE FILED
YES ☐ NO ☐

TYPE OF REPORT
PROPOSAL ☐
IN-PROGRESS ☒
FINAL ☐
FOLLOW-UP ☐

OTHER ERIC REFERENCES:

ERIC SATELLITE CODE

B. INDEXING DATA

14. SUBJECT AREA

15. TYPE OF ENDEAVOR
manual

16. INDEXING TERMS (6-12)

manuals O-09	professional edu. P-20	
curriculum R-53	textbooks Y-29	laboratories O-00
engineering edu. G-14	teaching aids Y-22	buildings and equipment R-28

17. ABSTRACT (MAX. 250 WORDS)

Reviews suggested procedure and outline for introductory course in fluid power. Presents 18 lesson plans, reference textbooks, recommendations for teaching aids, and laboratory equipment.

ERIC No.

18. SOURCE OF ABSTRACT

C. FUNDING DATA

19. SUPPORTING ORGANIZATION	20. DIVISION OR DEPT.	21. CONTRACT NO. / PROJECT NO.
	22. TOTAL COST OF PROJECT	
	23. DURATION OF PROJECT	U.S. Department of Health, Education, and Welfare Office of Education

ERIC Form 1

IV-5 (Engineering)

* *

" A

COURSE OUTLINE

FOR

AN INTRODUCTION TO FLUID POWER."

Course Description

A broad, general and practical coverage of fluid mechanics, fluid power components and their design, application, operation and maintenance. The course also covers pertinent standards, symbols, diagrams and circuit design problems common to the field of automation.

This review copy of a suggested procedure and outline for the offering of an introductory course in fluid power has been prepared under the direction of the NFPA Education Committee

It has been prepared without prejudice of any kind and with the realization that adjustments and improvements will be necessary.

We, therefore, solicit your comments and will appreciate receiving any recommendations for revisions you may offer.

When fully approved, additional copies may be obtained from NFPA Headquarters.

EDUCATION COMMITTEE

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education

This document has been reproduced exactly as received from the person or organization originating it. Points of view or opinions stated do not necessarily represent official Office of Education position or policy.

NATIONAL FLUID POWER ASSOCIATION

5595 N. Hollywood Ave. MILWAUKEE 17, WIS. WOodruff 2-9950

ED000334

N F P A C O U R S E O U T L I N E

SCOPE

An introductory, general survey type course to acquaint students with the fluid power language, the basic fundamentals of fluid mechanics as applied to fluid power system design and to give a basic understanding of the components available, their design, application, operation and maintenance. (Adaptable to Term or Semester basis with or without a laboratory period)

PURPOSES

1 - To give technicians a working knowledge of the art of applying fluid power and to acquaint them with its relationship to other branches of engineering.

2 - To aid in the retraining or in giving special training to people engaged in jobs affected by automation.

3 - To broaden and strengthen engineering curriculum.

4 - To acquaint management, designers, purchasing agents, sales people, etc., with the language of fluid power and its practicalities.

5 - To give an exploratory course which acquaints students with the fluid power field in their pursuit of a career.

6 - To give supplementary training and a more thorough understanding of fluid power to people engaged in its design, application, maintenance and operation.

GENERAL OUTLINE

LESSON	SUBJECT
1	Scope, introduction, evolution of the progress and advantages of fluid power
2	Nomenclature and fundamental principles of fluid mechanics
3	Principles of flow and properties of fluids
4	Conductors, seals and conditioning equipment
5	Standards and symbols, pressure theory and introduction to pumps and compressors
6	Fixed volume pumps
7	Variable volume pumps
8	Combination pumps, drives and power units

GENERAL OUTLINE (Cont'd)

9 - Review, test and evaluation

10 - Directional control devices

11 - Pressure control devices

12 - Flow controls and servo devices

13 - Cylinders, actuators, accumulators and intensifiers

14 - Controls and control systems

15 - Basic circuits: Unloading, speed control, sequencial, press, intensifier, pilot operated, rotary, pressure regulating and locking

16 - Continued circuitry in mobile, agricultural, aircraft and missile application

17 - Design problems, safety and review

18 - Test, evaluations and recommendations

COURSE TEXT

Because of the extensive coverage of this course, it is recommended that text materials be correlated from reference information and literature of fluid power component manufacturers.

REFERENCE TEXT BOOKS

1 - "Fluid Power Controls" Pippenger and Koff (McGraw-Hill Publishing Co.)

2 - "Hydraulic and Pneumatic Power for Production" H.L. Stewart (The Industrial Press)

3 - "Hydraulic Application and Control of Machines" I. McNeil (Ronald Press)

4 - "Fluid Power Directory" (current issue) (Industrial Publishing Company)

5 - "Oil Hydraulic Power and Its Industrial Applications" Walter Ernst (McGraw-Hill Publishing Co.)

6 - "Basic Hydraulics" (U.S. Government Printing Office) NAVPERS - 16193

RECOMMENDED VISUAL AID EQUIPMENT

1 - 16 MM Sound Projector
2 - Vu-Graph (Overhead Projector)
3 - 2 X 2 Slide Projector
4 - Screen

HELPFUL AIDS

1 - Cutaways of pumps, valves, cylinders, controls and related equipment. (These may be obtained through the cooperation of the various manufacturers of fluid power equipment either on a loan or consignment basis)

2 - Slide-lecture programs are available from many of the leading manufacturers of fluid power equipment and can be scheduled on a loan basis. A few of these companies are:

Racine Hydraulics & Machinery, Inc., 2000 Albert Street, Racine, Wisconsin
Automatic Switch Co., Florham Park, New Jersey
Logansport Machine Company, Inc., Logansport, Indiana
Flick-Reedy Corporation, 7N015 York Road, Bensenville, Illinois
Denison Engineering Division, Columbus 16, Ohio

Modernair Corporation, 400 Preda Street, San Leandro, California
Westinghouse Air Brake Company, Box 36, Wilmerding, Pennsylvania

3 - 16 MM Films are available from many of the leading manufacturers of fluid power equipment and can be scheduled on a loan basis. Consult the following:

Anker-Holth Division, 2823 Conner Street, Port Huron, Michigan
Mechanical Air Controls, Inc., 10030 Capital, Detroit 37, Michigan
Mead Specialties Company, 4114 North Knox Avenue, Chicago 41, Illinois
Galland-Henning Mfg. Co., 2753 South 31 Street, Milwaukee 46, Wisconsin
The Oilgear Company, 1560 West Pierce Street, Milwaukee 4, Wisconsin

The Bellows Company, P. O. Box 631, Akron 9, Ohio
Monsanto Chemical Company, 800 Lindbergh, St. Louis 66, Missouri
The Texas Company, (Consult local office)
Denison Engineering Division, Columbus 16, Ohio
Adel Precision Products, 10777 Van Owen Street, Burbank, California
John S. Barnes Company, Rockford, Illinois

4 - Helpful literature. The following companies furnish educational literature free of charge in reasonable quantities.

Automatic Switch Company, Valves, Florham Park, New Jersey
Logansport Machine Co., All components, Logansport, Indiana
Mechanical Air Controls, Inc., Valves, 10030 Capital, Detroit 37, Michigan
Flick-Reedy Corp., Cylinders, boosters, seals, 7N015 York Rd., Bensenville, Ill
The Oilgear Co., Power units, drives, rotary devices, 1560 Pierce, Milw.,Wis.

Racine Hydraulics, All components, 2000 Albert Street, Racine, Wisconsin
S-P Mfg. Company, Cylinders, 30201 Aurora Road, Solon, Ohio
Tomkins-Johnson Company, Cylinders, 2425 West Michigan Ave., Jackson, Michigan
Westinghouse Air Brake Co., Valves, cylinders, Box 36, Wilmerding, Penna.
Modernair Corp. Valves, cylinders, 400 Preda Street, San Leandro, California

Parker-Hannifin Corp., Tube fittings, 17325 Euclid Ave., Cleveland 12, Ohio
Rivett, Inc., Valves, cylinders, 18 Riverview Road, Brighton 35, Boston, Mass.
Northern Ordnance, Inc., Pumps, Minneapolis 21, Minnesota
Greer Hydraulics, Accumulators, N. Y. International Airport, Jamaica 30, N.Y.
Vickers, Inc., Manual pumps, valves, cylinders and units, Detroit 32, Michigan

4 - Helpful Literature (Cont'd)

E. F. Houghton Co., Fluids, seals, Philadelphia, Pennsylvania
Viking Pump Corp., Pumps, Cedar Falls, Iowa
John S. Barnes, Pumps, valves, cylinders and units, Rockford, Illinois
The Texas Company, Basic Text, (Consult local office)
Shell Oil Company, Basic Text, (Consult local office)
Chicago Rawhide Mfg. Co., Seals, 1301 Elston Ave, Chicago, Illinois
Socony Mobile, Basic Text, (Consult local office)
Standard Oil Company, Basic Text, (Consult local office)
Sun Oil Company, Basic Text, (Consult local office)
Cities Service Oil Corp., Basic Text (Consult local office)

5 - Mobile Demonstration Units

Flick-Reedy Corporation, 7N015 York Road, Bensenville, Illinois
Modernair Corporation, 400 Preda Street, San Leandro, California

6 - Periodical Publications covering fluid power

Applied Hydraulics & Pneumatics
Machine Design
Product Engineering
Design News
Automation
Tool Engineer
Production
The Iron Age
Tooling & Production
Plant Engineering
The Plant
Machinery
Compressed Air
Machine & Tool Blue Book
Instruments & Automation
American Machinist
Metlfax Magazine

7 - Resource Persons from the Fluid Power Industry (Consult-National Fluid Power Assn.

RECOMMENDED PROCEDURES

To facilitate the extensive coverage of this course, it is essential to use wherever possible films, slides, diagrams, transparencies, cutaways and other aids to supplement lectures.

Vu-Graph transparencies are of the utmost importance because they are readily adaptable and easily made direct from cross-sectional views of components which appear in manufacturers catalogs, etc. (Consult local Vu-Graph dealers for details) Valuable time can be saved through advanced preparation of transparencies of formulae, components, circuits, charts, graphs, tables, etc.

Colored pencils can be used very effectively by students in analyzing components or circuits in terms of pressure fluid, exhaust fluid, drain lines, pilot pressure, metered fluid, etc.

Large charts of circuits or components are valuable to present typical design application, etc.

Mobile demonstration units should be utilized where practical.

A number of elementary 16 MM films are available on the basic fundamentals:

* Basic Hydraulics by Adel Precision Products
Harnessing Liquids by Syracuse University
Derivation of Pascal's Law: Part I - Castle Films, Inc.
Derivation of Pascal's Law: Part II - Castle Films, Inc.
Application of Pascal's Law: Part I - Castle Films, Inc.
Application of Pascal's Law: Part II - Castle Films, Inc.
* Fluid Flow in Hydraulic Systems by Adel Precision Products

*Excellent for any program. May also be obtained through Oilgear Company

A number of the fluid power component manufacturers have developed 16 MM films for sale promotional work and these can have great value if correlated properly into the pertinent lesson. It is suggestion that all films be previewed and evaluated for possible use.

Slide lecture programs, demonstrations, cutaways, etc., should be utilized throughout the entire course wherever pertinent. In many areas there are resource persons available to cover special subjects and should be utilized to good advantages.

The various pieces of literature obtained from component manufacturers should be carefully fitted into the dourse. The various manufacturers have gone to a considerable amount of expense to compile charts, diagrams, nomographs, sample design problems and to author valuable text material that is not obtainable elsewhere. A subject reference list should be supplied to each student to correlate the information materials with the course content.

Periodic quizes, homework assignments, a midterm and a final exam help to maintain interest and serve as a check for improving the course.

Semester projects for individuals, or groups can be used very effectively to cope with a class composed of various levels of experience. This is especially true with adult groups with a wide spread to keep the higher level students motivated.

Students should be given every opportunity to participate in helping to build aids, set up experiments, and to present unique circuits or problems.

RECOMMENDATIONS FOR LABORATORY EQUIPMENT

Laboratory equipment that would lend itself more effectively to this course should be flexible in nature. The various pumps, valves, cylinders, motors and related equipment should be provided with means of testing before and after any disassembly by students. To accomplish this a horizontal or vertical mounting panel can be used in connection with a power unit and using quick disconnect fittings with flexible hoses. This would give a flexible arrangement for testing cylinders, motors and controls.

A pump testing station can be made quite readily by using a variable speed drive, a fixture which can clamp a variety of pumps and facilitate quick coupling with the drive. A flow meter, gages, tachometer, safety controls, etc., are a few of the essential refinements to complete a more meaningful utility of the apparatus.

Laboratory equipment which is portable and can be used for demonstration purposes is especially effective for conducting this course. The apparatus could be a relatively simple unit consisting of a reservoir, electric motor and small pump. The pump could discharge through a series of three relief valves each fitted with a gage and set for a descending value. The third valve would discharge back to the reservoir. A number of good problems could be worked out in connection with such equipment.

Another effective hook-up would be to show an automatic reciprocating circuit incorporating a flow control, pressure switch gages, etc.

However, expensive and elaborate equipment is not absolutely essential to this course.

COURSE OUTLINE

FOR

AN INTRODUCTION TO FLUID POWER

LESSON NO. 1

A - Purposes

1 - To give students the scope, contents and procedure of the course.
2 - To acquaint students with the evolution of fluid power progress.
3 - To give illustrations and examples of some of the advantages of fluid power.

B - Introduction

1 - Scope of Course
2 - Class Procedure
3 - Credit
4 - Tests, Homework and Grading
5 - Special Projects, etc.

C - The History and Evolution of Fluid Power Progress

1 - Early Applications
2 - Physical Laws
3 - Inventions
4 - Progress during World War II
5 - Fluid Power as a leading Industry

D - Advantages and Applications of Fluid Power

1 - Force Transmission
2 - Dimensions of Speed, Time and Distance
3 - Flexibility
4 - Circuit previews of Fluid Power at Work in Industry, Agriculture, Aircraft, Mobile Equipment, Automotive, Marine, Missile and Space Travel

LESSON NO. 2

A - Purposes

1 - To acquaint students with units of measurements and concepts of energy, force, work power, etc.
2 - To acquaint students with Pascal's Law and its applications
3 - To acquaint students with Newton's Laws and their applications
4 - To acquaint students with the gas laws and their applications

B - Fundamental Concepts and Units

1 - Potential and Kinetic Energy
2 - Force Pressure and Area
3 - Work and How it is Measured
4 - Power, Horsepower and Torque
5 - Relationship of the General Laws of Mechanics and Thermodynamics to Fluid Power

LESSON NO. 2 (Cont'd.)

C - Pascal's Law

1 - Derivation of Pascal's Law and its application
2 - Problems dealing with Force Multiplication through Liquid Pressure Intensification
3 - Fluid Properties

D - Newton's Laws and their Applications

E - Gas Laws and their Application to Fluid Power

1 - Boyle's Law in Application with Accumulators
2 - Charles' Law with Application to Compressors and Aftercoolers
3 - Principles of Compressible Flow

F - Introduction, Showing and Discussion of a Film or Films on the above Topics. Example Problems.

LESSON NO. 3

A - Purposes

1 - To acquaint students with Fluid Flow Characteristics and Laws or Principles that affect Fluid Power System Design
2 - To Study the Various Types of Fluids Available and the Effect of their Important Physical Characteristics on the System

B - Principles and Characteristics of Fluid Flow

1 - Darcy's Equation
2 - Bernoullis' Theorem
3 - Reynolds Number
4 - Viscosity Measurement
5 - SSU
6 - Absolute Viscosity
7 - Bulk Modulus
8 - Relationship of temperature, pressure, friction, inertia, gravity, velocity, etc. to flow and system design

C - Petroleum Fluids and Their Important Characteristics (There are a few good films and a number of resource persons available for this subject through the various fluids manufacturers)

1 - Paraffine, asphaltic and mixed base oils
2 - Viscosity Index, gravity, pour point, demulsibility, neutralization number, lubricity, carbon residual, film strength, stability, color, etc.
3 - Compatibility Factors

D - Fire Resistant $ EXOTIC $ SYNTHETIC Fluids Available

1 - Water Glycols
2 - Water Emulsions
3 - Phosphate Esters
4 - Halogenated Hydro-carbons
5 - Silicate Esters
6 - Diesters
7 - Silicones
8 - Additives

E - Fluid Maintenance and Service Requirements

LESSON NO. 4

A - Purposes

1 - To give students information and procedures for sizing and installation of tubing, pipe, hose and fittings
2 - To acquaint students with good sealing practices
3 - To acquaint students with the various conditioning equipment available and its application

B - Selection Factors for Conductors

1 - Materials Available
2 - Determining Wall Thickness
3 - Capacity requirements (Velocity - Laminar or Turbulent Flow)
4 - Fittings
5 - Hose Assemblies, etc.
6 - Cutting, Bending, and Flaring Tubing

C - Ports, Seals, Materials and Methods of Preventing Leakage

1 - SAE - Army-Navy Port Configuration and Threads
2 - Pipe Threads
3 - Sealing devices
4 - Application of Sealing Rings, Packing, Gaskets, etc., and their compatibility factors
5 - Flange Connectors
6 - Swivel and uick disconnect fittings
7 - Subplates and manifolds

D - Conditioning Equipment

1 - Reservoirs (JIC), Storage Tanks, Surge Tanks, etc.
2 - Separators, Receivers, Air Line Filters and Lubricators
3 - Coolers and Heat Exchangers
4 - Strainers and Filters, their Application and Maintenance

LESSON NO. 5

A - Purposes

1 - To acquaint students with graphical symbols and diagrams (JIC and ASA)
2 - To give students a basic understanding of pumping principles, nomenclature and Pressure phenomena
3 - To acquaint students with compressors and air motors
4 - To acquaint students with non-positive displacement pumps

B - Importance of a common language through the use of symbols, etc.

1 - History of JIC and ASA symbols and diagrams
2 - Application of symbols to each fluid power component and various controls
3 - NFPA, ASFP, MIL-Spec, Army and Navy Standards, etc.

LESSON NO. 5 (Cont'd)

C - Pumping Principles, Nomenclature and Pressure Theory

1 - Pump parts and their relationship to displacing fluids
2 - Suction lift, suction head, discharge head, pressure head, velocity head, etc.
3 - The part played by the atmosphere (absolute, atmospheric and vacuum measurements)
4 - Temperature, density and viscosity

D - Compressors and Air Motors

1 - Rotary single and two stage compressors
2 - Reciprocating compressors
3 - Axial turbine, radial piston, vane and gear motors

E - Non-positive Displacement Pumps

1 - Centrifugal type
2 - Axial flow type
3 - Mixed flow type

LESSON NO. 6

A - Purposes

1 - To acquaint students with positive displacement fluid power pumps their design, operation and application
2 - To give detailed information concerning fixed volume pumps of the gear, vane and piston designs
3 - To compare fluid power pumps and motors

B - General Classification of Positive Displacement Pumps or Motors

1 - Fixed volume pumps
2 - Variable volume pumps
3 - Staged pumps
4 - Combination pumps
5 - Combination units and drives
6 - Power units
7 - Specific requirements of capacity, H.P., Eff., Pressure, etc.

C - Fixed Volume Pumps of the Gear, Vane and Piston Designs - Their Operation and Application

1 - Spur gear
2 - Helical gear
3 - Herringbone gear design
4 - Screw, lobe and other versions
5 - Vane pumps (unbalanced)
6 - Vane pumps (balanced)
7 - Double vane pumps
8 - Staged or series designs
9 - Axial, radial and reciprocating piston pumps
10-- Comparison of motors and pumps

LESSON NO. 7

A - Purpose

1 - To acquaint students with the design, operation and application of variable volume vane, axial and radial piston-type pumps or motors

LESSON NO. 7 (Cont'd)

B - Variable Volume Vane Pumps

1 - Available designs
2 - Operation
3 - Circuit applications
4 - Maintenance and service requirements
5 - Methods of control
6 - Comparison of motors and pumps

C - Variable Volume Axial Piston Pumps

1 - Available designs
2 - Operation
3 - Circuit applications
4 - Maintenance and service requirements
5 - Metho[illegible] of control
6 - Comparison of motors and pumps

D - Variable Volume Radial Piston Pumps

1 - Available designs
2 - Operation
3 - Circuit applications
4 - Maintenance and service requirements
5 - Methods of control
6 - Comparison of motors and pumps

E - Cam Abutment and Other Designs

LESSON NO. 8

A - Purpose

1 - To acquaint students with the design, operation and application of combination pumping units
2 - To acquaint students with the design, operation and application of hydrostatic drives
3 - To acquaint students with the design, operation and application of power units

B - Combination Pumping Units

1 - Vane design combinations
2 - Gear design combinations
3 - Piston design combinations
4 - Special units

C - Hydrostatic Drives

1 - Constant torque (variable pump - constant motor)
2 - Constant H. P. (fixed volume pump - variable motor)
3 - Combination (variable volume pump - variable volume motor)

D - Power Units

1 - Pumping units
2 - Pumping units with controls
3 - Custom or special units

LESSON NO. 9

A - Purpose

1 - To review, test, evaluate and list recommendations for future changes in subject matter, methods of teaching, materials, time, etc.

LESSON NO. 9 (Cont'd)

B - Review

1 - Advantages
2 - Fluid mechanics
3 - Types of fluids
4 - Conductors, seals and conditioning equipment
5 - Pumping principles
6 - Pumps and motors

C - Test

D - Evaluation

LESSON NO. 10

A - Purpose

1 - To acquaint students with the design, operation and application of directional control valves

B - Straightway Valves (Simplex)

1 - Gate valves
2 - Globe valves
3 - Check valves (1-way and 2-way pilot checks)
4 - Needle valves
5 - Butterfly valves
6 - Foot valves
7 - Ball valves
8 - Plug valves
9 - Cocks

C - Poppet Valves

1 - 2, 3 and 4-way valves
2 - Maximum allowable pressure
3 - Pressure drop through valve
4 - Methods of shifting
5 - Adaptability to control
6 - Servo applications

D - Slide Plate Valves

1 - 2, 3 and 4-way valves
2 - Maximum allowable pressure
3 - Pressure drop through valve
4 - Methods of shifting
5 - Adaptability to control
6 - Servo applications

E - Rotary Valves

1 - 2, 3 and 4-way valves
2 - Maximum allowable pressure
3 - Pressure drop through valve
4 - Methods of shifting
5 - Adaptability to control
6 - Servo applications

F - Spool Valves

1 - 2, 3 and 4-way valves
2 - Maximum allowable pressure
3 - Pressure drop through valve
4 - Methods of shifting
5 - Adaptability to control
6 - Servo applications

G - Special Valves

1 - Prefill check valves

LESSON NO. 11

A - Purpose

1 - To acquaint students with the design, operation and application of pressure control valves

B - Simplex Pressure Valves

1 - Direct acting
2 - Pilot operated
3 - Remote
4 - Sequence
5 - Pressure reducing
6 - Unloading
7 - Pressure volume characteristics
8 - Stability
9 - Response - override
10 - Sensitivity - hysteresis loop
11 - Circuit application illustration

C - Compound Pressure Valves

1 - Direct acting
2 - Pilot operated
3 - Remote
4 - Sequence
5 - Pressure reducing
6 - Unloading
7 - Pressure volume characteristics
8 - Stability
9 - Response-override
10 - Sensitivity-hysteresis loop
11 - Circuit application illustrations

D - Special Pressure Control Valves

1 - Surge valves
2 - Shuttle valves
3 - Motor overload, etc.

LESSON NO. 12

A - Purpose

1 - To acquaint students with the design, operation and application of flow control valves
2 - To acquaint students with the design, operation and application of panels, combination controls and servo valves

B - Fixed Orifice Flow Metering Controls

1 - Orifice plates
2 - Orifice checks
3 - Capilliary tubes
4 - Restrictors
5 - Flow characteristic with respect to pressure, temperature, fluid viscosity, etc.
6 - Metering in - metering out - bleed off circuits

C - Variable Orifice Flow Metering Controls

1 - Needle valves
2 - Adjustable orifice type
3 - Braking valves
4 - Deceleration valves
5 - Foot valves
6 - Flow dividing valves
7 - Flow characteristics with respect to pressure, temperature, fluid viscosity, etc.
8 - Metering in - metering out - bleed off circuits

LESSON NO. 12 (Cont'd)

D - Pressure and Temperature Compensated Flow Metering Controls

1 - Hydrostatic compensating devices
2 - Temperature compensating devices
3 - Combination units
4 - Flow characteristics
5 - Metering in - metering out - bleed off circuits

E - Panels, Combination Controls and Servo Valves

1 - Pressure, flow and directional panels
2 - Special control assemblies
3 - Circuit applications
4 - Servo valves

LESSON NO. 13

A - Purpose

1 - To acquaint students with the design, operation and application of fluid power cylinders
2 - To acquaint students with the design, operation and application of linear and rotary actuators
3 - To acquaint students with the design, operation and application of accumulators, intensifiers and shock absorbers

B - Hydraulic and Pneumatic Cylinders

1 - Plunger and piston types
2 - Mountings
3 - Volumetric input
4 - Stroke conditions
5 - Pressure areas
6 - Functional designs
7 - Cushion and seals

C - Linear and Rotary Actuators

1 - Stroke adjustment
2 - Adaptability to control
3 - Indexing or positioning applications
4 - Servo applications

D - Accumulators and Intensifiers

1 - Hydropneumatic
2 - Weighted type
3 - Spring loaded
4 - Pneumatic
5 - Steam-hydraulic
6 - Capacity and pressure
7 - Safety in application
8 - Circuit illustrations

E - Intensifiers

1 - Differential piston and plunger type
2 - Automatic reciprocating type
3 - Flow, force, pressure and area factors
4 - Circuit illustrations

F - Shock Absorbers

1 - Sock type
2 - Accumulator type

LESSON NO. 14

A - Purpose

1 - To acquaint students with the designs, operation and application of gages, pressure switches, hydraulic fuses, recording instruments and fluid meters

2 - To acquaint students with the designs, operation and application of such electrical controls as fuses, overloads, switches, solenoids, relays, limit switches, time delays and servos.

3 - To acquaint students with electrical symbols and diagrams for control systems as used with fluid power systems.

B - Fluid Power Controls and Instruments

1 - Compound gages
2 - Pressure gages
3 - Vacuum gages
4 - Gage cut-offs
5 - Gage testers
6 - Hydrauliscopes and oscilloscopes
7 - Head meters and liquid volume meters
8 - Pressure switches
9 - Hydraulic fuses

C - Electrical Controls used with Fluid Power Systems

1 - Types of fuses
2 - Thermol overloads
3 - Line, palm, safety and push-button switches
4 - Solenoids
5 - Limit switches
6 - Relays
7 - Timer devices
8 - Servo devices

D - Symbols and Diagrams

1 - Importance
2 - Develope a simple control circuit and explain the function of each symbol
3 - Develop a fluid power circuit for a feed and traverse system using limit switches and a pressure switch to actuate valves.
4 - Develop an electrical control circuit for the fluid power system
5 - Safety factors

LESSON NO. 15

A - Purpose

1 - To acquaint students with a number of the typical fluid power circuits as applied to the machine tool industry
2 - To show a correlation of the various fluid power components to practical applications
3 - To show principles of good circuit design

B - Unloading Circuits

1 - Combination valve assembly
2 - Venting the relief valve
3 - Comparison of fixed volume pumps to variable volume pumps
4 - Open-center systems
5 - Closed-center systems

LESSON NO. 15 (Cont'd)

C - Speed Control Circuits

1 - Flow rate metering circuits
2 - Differential circuits
3 - Accumulator circuits

D - Sequencing Circuits

1 - Sequence valve application
2 - Directional valve application

E.- Press Circuits

1 - Tensional presses
2 - Compressional applications
3 - Prefill devices
4 - Decompression
5 - Kicker cylinders

F - Intensifier or Booster Circuits

1 - Riveting circuits
2 - Extruding circuits
3 - Forging, forming, etc.
4 - Combination Air-Oil circuits

G - Pilot Operated Circuits

1 - Oil 2 - Air 3 - Combination

H - Rotary Fluid Motor Circuits

1 - Indexing 2 - Reel winding 3 - Drives, etc.

I - Pressure Regulating Circuits

1 - Clamping circuits
2 - Air
3 - Oil
4 - Control Circuits

J - Locking Circuits

K - Filter Installations

LESSON NO. 16

A - Purposes

1 - To acquaint students with a number of the typical fluid power circuits as applied to mobile, agricultural, aircraft and missile.
2 - To show a correlation of the various fluid power components to practical applications
3 - To show principles of good circuit design

B - Mobile and Agricultural Implement Applications

1 - Control circuits
2 - Fluid power systems
3 - The application of high pressure systems
4 - Selector circuits
5 - Maintenance and service

LESSON NO. 16 (Cont'd)

C - Aircraft and Missile Applications

1 - Control circuits
2 - Fluid power systems
3 - Servo systems
4 - Application of high pressure systems
5 - Safety and reliability factors

LESSON NO. 17

A - Purpose

1 - To review, evaluate, clear up any misunderstandings, complete class projects and prepare for the final examination

B - Review

1 - Directional valves
2 - Pressure control valves
3 - Flow metering valves
4 - Fluid power cylinders
5 - Linear and rotary actuators
6 - Accumulators
7 - Intensifiers
8 - Fluid controls
9 - Electrical controls used for fluid power systems
10 - Circuit design problems
11 - Safety

LESSON NO. 18

A - Purpose

1 - To evaluate the course, teaching and students
2 - To facilitate future additions, deletions or revisions to the subject matter and methods of teaching
3 - Supplement weak areas with teaching aids, laboratory equipment, etc.

B - Final Examination

C - Grading, Marking, Evaluations and Recommendations

Rough Draft:

1/12/59

Prepared by Dudley Pease